

Geological background of shallow landslides induced by rainstorms

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Background of today's talk

- Shallow landslides are failure of surface materials.
- They have long been considered not controlled by bedrock geology.
- Our experience tells that it is not.
- It is due to that weathering profiles are characteristic to rock types.
- There are various rock types.
- I would like to show you various types of shallow rain-induced landslides mainly from Japan.

A list of rainfall-induced landslides in Japan

Year	Place	Geology	Deep-seated	Shallow
2003	Hokkaido	Accretionary complex	-	○
2004	Mie	Accretionary complex	○	-
2005	Miyazaki	Accretionary complex	○	-
2011	Nara, Wakayama	Accretionary complex	○	-
2004	Tokushima	Accretionary complex	○	-
1999	Hokkaido	Sedimentary soft rock	-	○
2003	Hokkaido	Sedimentary soft rock	-	○
1989	Chiba	Soft mudstone	-	○
2004	Niigata	Soft mudstone	-	○
1998	Fukushima	Moderately welded ignimbrite	-	○
1993	Kagoshima	Unwelded ignimbrite	-	○
1995	Kagoshima	Unwelded ignimbrite	-	○
2004	Fukui	Tuff	-	○
2012	Kumamoto	Volcanic ash	-	○
2013	Izu (Tokyo)	Volcanic ash	-	○
2006	Nagano	Volcanic soil	-	○

Data added to Chigira (2018, A note for hazard geology)

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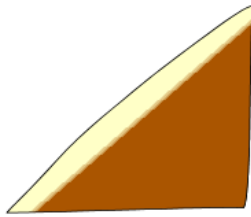
A list of rainfall-induced landslides in Japan (continued)

Shallow landslides and deep-seated landslides tend to occur on different bedrocks

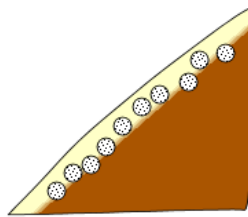
Year	Place	Geology	Deep	Shallow
1997	Kagoshima	Andesite, Tuff breccia	○	△
2003	Kagoshima	Andesite lava	○	○
2017	Oita	Andesite lava, Pyroclastics	○	△
1999	Hiroshima	Granite	-	○
2000	Aichi	Granite	-	○
2009	Yamaguchi	Granite	-	○
2018	Hiroshima	Granite	-	○
2014	Hiroshima	Granite, Hornfels	-	○
2017	Fukuoka	Granodiorite, Hornfels	-	○
2000	Kozu Island (Tokyo)	Rhyolitic pyroclastics	-	○
2010	Hiroshima	Soil on rhyolite	-	○
2018	Hiroshima	Rhyolite	-	○
2004	Ehime	Schist	○	○
2017	Fukuoka	Schist	○	○
2004	Ehime, Kagawa	Sandstone	-	○
2018	Ehime	Sandstone and mudstone	-	○

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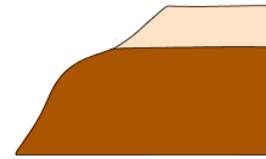
There are various structures susceptible to rain-induced shallow landslide



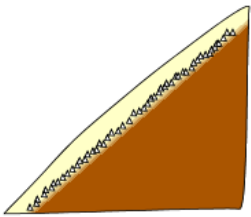
Surface layer consists of loose layer, which overlies less permeable bedrock with clearly defined boundary



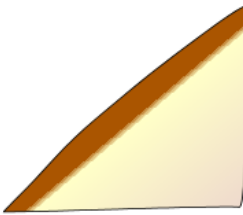
Surface layer consists of loose layer that include boulders



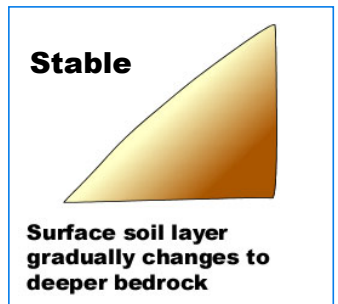
Horizontal permeable beds overlies less permeable beds



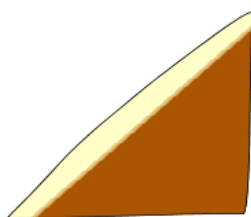
Hard debris occupy the base of soil on bedrock



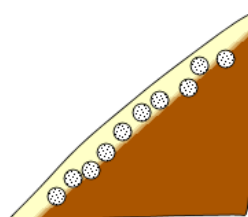
Finer surface layer overlies coarser materials with clearly defined boundary



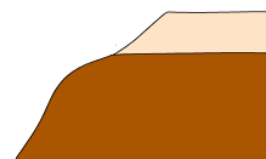
Various structures susceptible to rain-induced shallow landslide



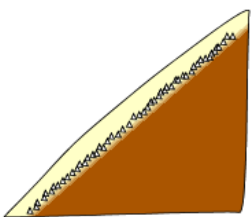
Surface layer consists of loose layer, which overlies less permeable bedrock with clearly defined boundary



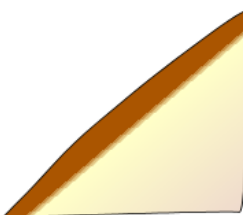
Surface layer consists of loose layer that include boulders



Horizontal permeable beds overlies less permeable beds



Hard debris occupy the base of soil on bedrock



Finer surface layer overlies coarser materials with clearly defined boundary

**Moderately welded
ignimbrite**

Discontinuity at 1-2m
depth by weathering

1998 Fukushima

Chigira et al. (2002, Eng. Geol.)

Pore
pressure
buildup

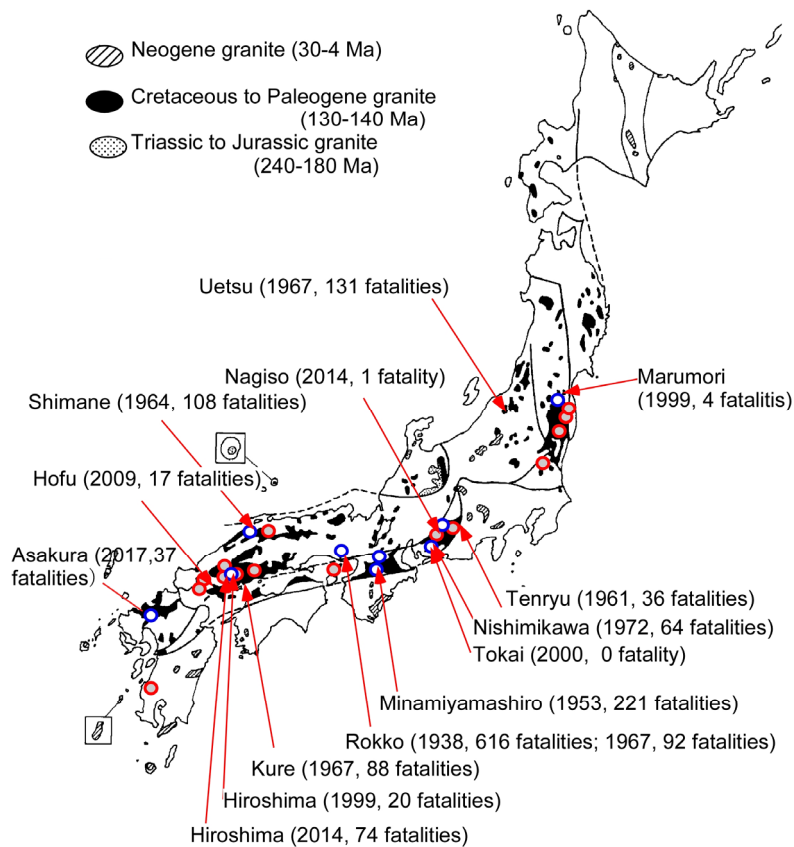
Granite

Weathered micro-sheeted
granite

2002 Korea

Sediment yielded without
rock blocks

Rain-induced landslides in granitic areas

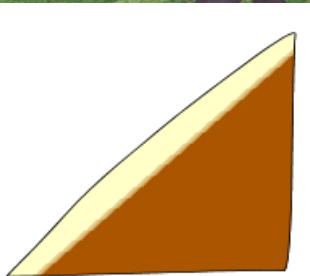


Data added to Chigira et al. 2016. Engineering Geology. *The Geology of Japan. Geological Society, London*, 461-487.

Volcanic ash

Permeable ash
on impermeable
soil

2012 Kyushu



Mudstone

500 m

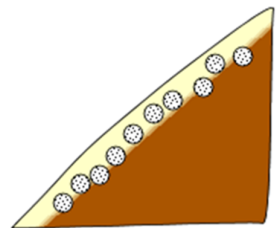
New Zealand
(Google Earth, North Island)

Weathering front

Chigira, 1990 Eng. Geol. 29, 119-138.

Granite

Piping erosion of saprolite



Surface layer consists of loose layer that include boulders

2018 Hiroshima

Granite

Corestones in the saprolite

2019 Miyagi

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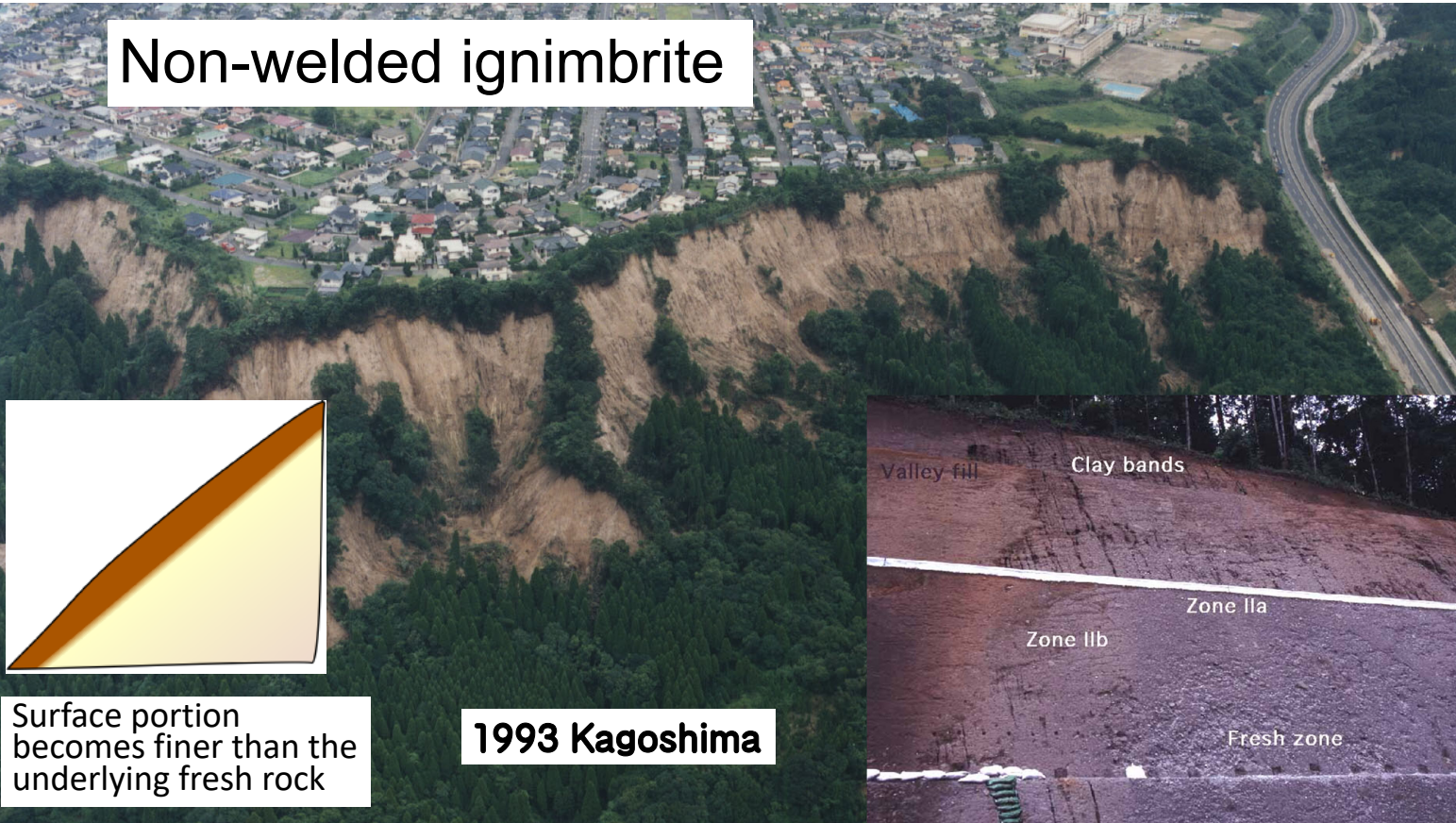
Hornfels

Soil is eroded to form drainage path in the framework

2014 Hiroshima

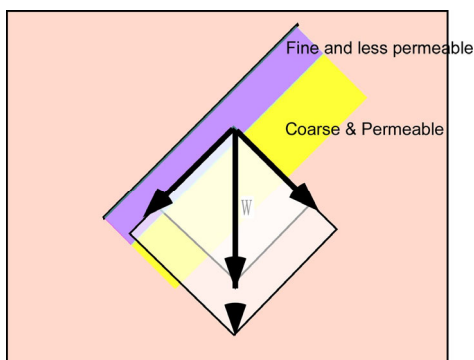
Hard debris occupy the base of soil on bedrock

Non-welded ignimbrite

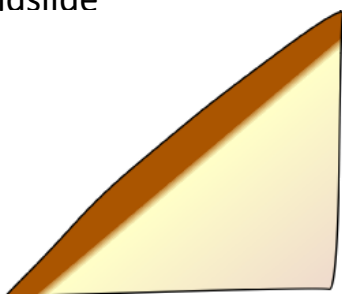


Surface portion becomes finer than the underlying fresh rock

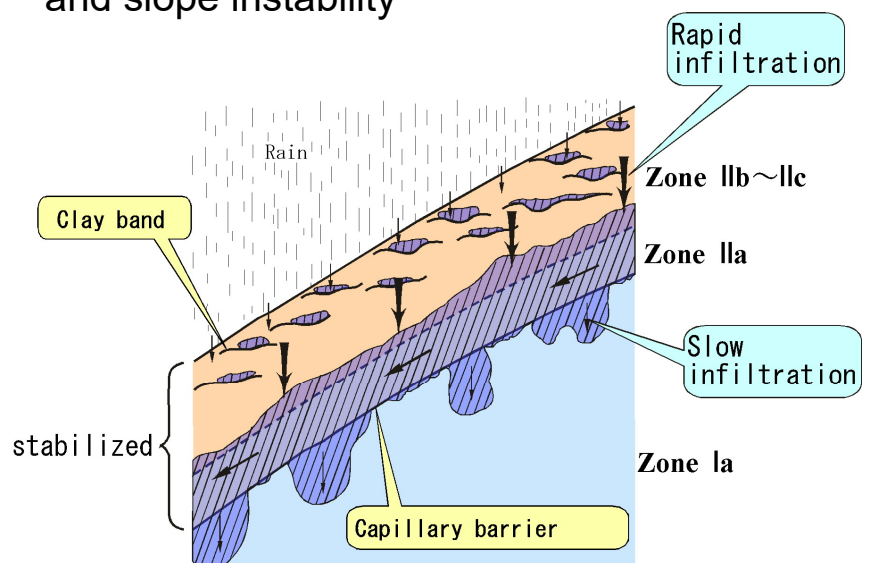
1993 Kagoshima



No pressure build up occurs, but weight increase and the decrease of suction are the main cause of landslide

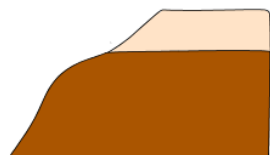
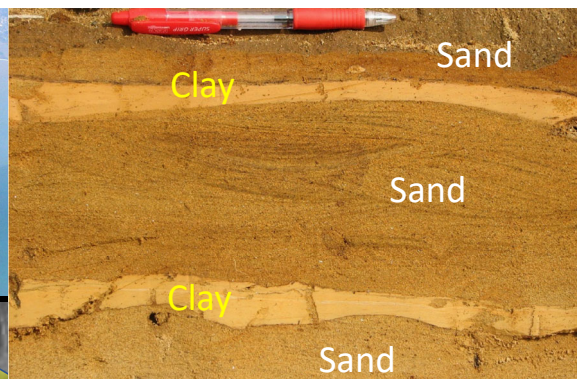
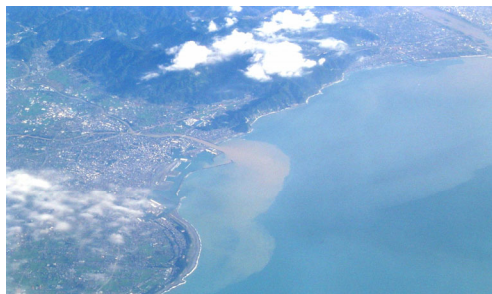


Conceptual model of water infiltration and slope instability

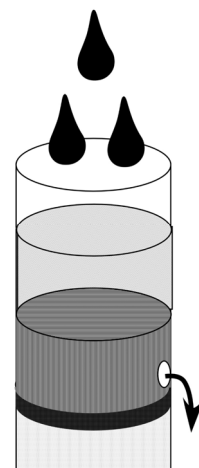
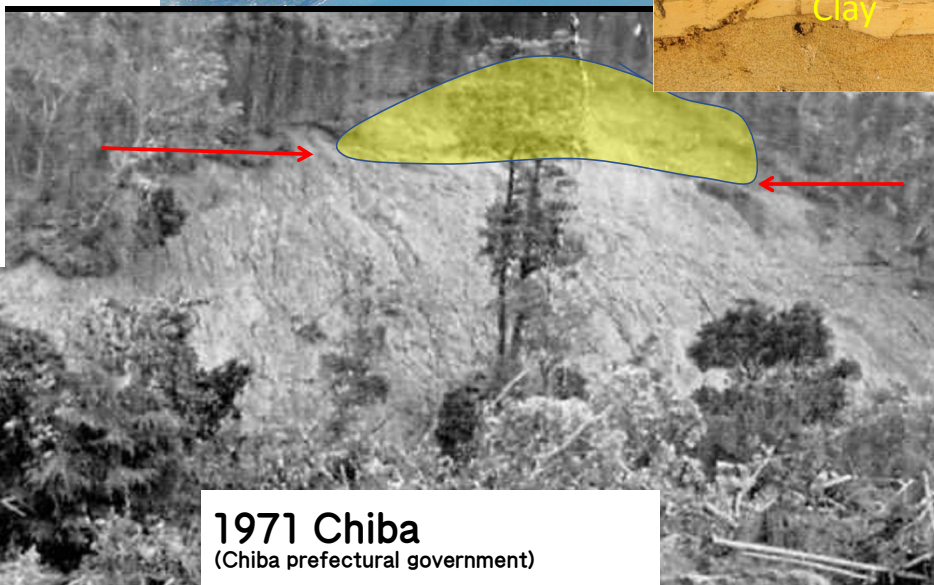


Chigira, M., Yokoyama, O., 2005.
Eng. Geol., 78, 187-207.

Storm deposits

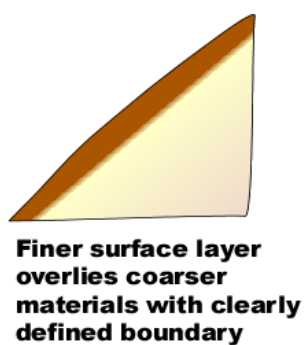
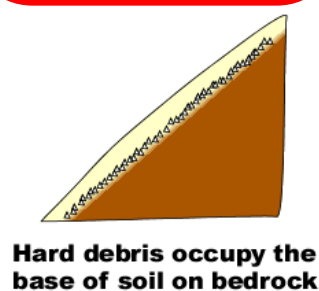
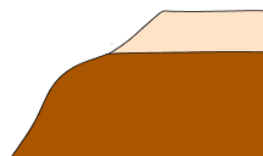
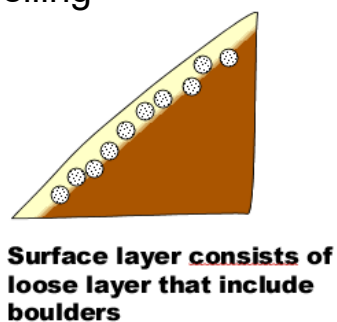
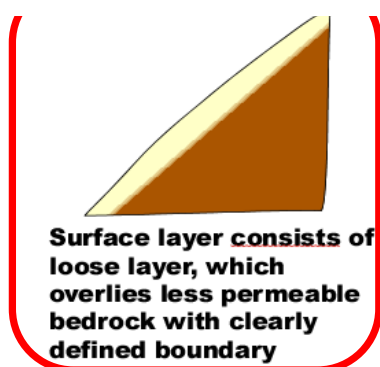


Horizontal permeable
beds overlies less
permeable beds



Conclusions

Dominant landslide modelling



Landslide modelling should
be consistent with
geological structures